Combining the genetic algorithms with artificial neural networks for optimization of board allocating

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Abstract: This paper introduced the Genetic Algorithms (GAs) and Artificial Neural Networks (ANNs), which have been widely used in optimization of allocating. The combination way of the two optimizing algorithms was used in board allocating of furniture production. In the experiment, the rectangular flake board of 3650 mm ×1850 mm was used as raw material to allocate 100 sets of Table Bucked. The utilizing rate of the board reached 94.14 % and the calculating time was only 35 s. The experiment result proofed that the method by using the GA for optimizing the weights of the ANN can raise the utilizing rate of the board and can shorten the time of the design. At the same time, this method can simultaneously searched in many directions, thus greatly increasing the probability of finding a global optimum.

Keywords: Artificial neural network; Genetic algorithms; Back propagation model (BP model); Optimization
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Introduction

Board allocating as an important part in furniture production should satisfy the fact that a set of figures is allocated in one sheet and the scrap is lest. The normal searching process of the answer for board allocating needs long time and is very complex. Up to date, there has not been a general standard algorithm for board allocating.

Neural network has been widely applied in nesting and stock cutting. The majorities of these applications are the gradient technique and back propagation for optimizing the networks. Back propagation (BP) has unquestionably been a major technique, but it is plagued with long practicing and unpredictable performance (Zhou *et al.* 1996).

Genetic algorithm (GA), based on natural selection and genetic mechanism, is a global search that grabbles from one population of points to another. As the algorithm continuously samples the parameter space, the search is directed toward the area of the best solution (Goldberg 1989; Fang *et al.* 1994). The combination of the Artificial neural network (ANN) and Genetic algorithm is a potential and effective method.

This paper uses the Genetic algorithm to train the interconnection weights of multi-layer feed forward Artificial Neural network (ANN) in board allocating. This method gives encoding measure of the multi-layer feed forward Artificial neural network. The paper also introduced how Genetic algorithm train the interconnection weights by this method.

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Genetic algorithm

Genetic algorithm combines Darwinian's survival of the fittest and the crossover operation and accelerates the optimizing speed and capability. It starts with the initial population by randomly choosing, and each answer is expressed as a string. These candidates go along for better answer by the combination of strings. The general Genetic algorithm is composed of reproduction, crossover and mutation, which simulate propagating, mating and gene mutation of natural selecting and inheritance course (Chen *et al.* 1996). The steps of Genetic algorithm are as follows:

- Definine an objective function.
- Initialize population.
- Calculate the values of evaluating function of each chromosome. These values are then used in assigning probabilities for each of the points in the population.
- Randomly choose the points by the probability of selection equal to its assigned probability value to generate a new population.
- Randomly pair the points from the new population for the crossover operation and mutation operation to generate offspring.
- Repeat the step 3, 4 and 5 until the chromosome satisfies the given probabilities.

Artificial neural networks

There are many types of Artificial Neural Network. In this section we discuss one model, which is called Back Propagation model (BP model), (Zuo *et al.* 1994). Neural networks are built from a large number of very simple processing elements that can individually deal with information. A processing element (PE) simply multiplies an input by a set of weights, and a nonlinear result is transformed into an output value. The principles of computation at the PE level are deceptively simple. The power of neural

computation comes from the massive interconnection between PEs, which share the load of the overall processing task, and from the adaptive nature of the parameters (weights) that interconnect the PEs.

Applying Genetic algorithms in artificial neural network

There are three steps in the course of optimizing the weights of Artificial Neural Network by Genetic algorithm. First, define the structure of the ANN; second, define the encoding of the interconnection weights; third, optimize the interconnection weights of the ANN by GA.

Structure of the neural networks

The sample given in this study is based on a modified BP model applied in furniture board allocating. The input of this modified network, X, represents the quantities of different patterns needed in a procedure. The output Y represents the quantities of different patterns in a sheet. The output function of this network:

$$Y_j = F(\sum W_{ij} X_i - \theta_j)$$

where, $F(\cdot)$ is the function that can activate the unit when $\sum W_{ij}X_i$ is greater than θ_j, W_{ij} is the interconnection weight between unit i and unit j, X_i is the input of the unit, Y_j is the output of the unit, and θ_j is the value in the unit j.

Encoding project

Each point is a string of n weights. Since the encoding project always affects the training time and the accuracy, our experiment adopted the integration of binary bit string and decimal bit string. For the input and output we adopted decimal bit string to express the quantities of each pattern. As to the weights we adopted the binary bit string with a view to crossover operation and mutation operation in GA.

Optimizing artificial neural network by genetic algorithm

The course of the neural networks, which is based on genetic algorithm, is learning, applying then learning. First, define the interconnection weights of the network of the same structure, after then optimize the interconnection weights by GA until the result of the output meet the demand of the evaluating function.

The steps of GA used in training ANN (Luo 1995) are as follows:

- Define the weights encoding project, then initialize the points.
- Define the structure of the network by the given input and output specimens.
- Calculate the evaluating function in the light of some criterions.
- Generate new point by crossover operation and mutation operation.
- Repeat step 3 until the optimized weights satisfies the evaluating function.

Experiment

The initial data of an allocating workshop were used for this experiment, and the patterns were allocated by the combination of genetic algorithms and artificial neural networks. According to the method discussed above, we used rectangular Flake Board of 3650 mm ×1850 mm as raw material to allocate 100 sets of Table Bucked. The size of each part is shown in Table1. The utilizing rate of the board reached 94.14 % and the calculating time was only 35 seconds.

Table 1. Parts size of Table Bucked

Part No.	Name of parts	Specification		
		Length /mm	Width /mm	Quantity (Pieces)
8-01	Left outer leaf	443	356	1000
8-02	Right outer leaf	443	356	1000
8-03	Top/bottom leaf	443	397	2000
8-04	Drawer surface	431	171	2000
8-05	Drawer left outer Leaf	419	119	2000
8-06	Drawer right outer leaf	419	119	2000
8-07	Drawer back	356	119	2000
8-08	Drawer bottom	412	362	2000

Conclusions

The experiment result proofed that the method by using the GA for optimizing the weights of the ANN can raise the utilizing rate of the board and can shorten the time of the design. At the same time, this method can simultaneously searches in many directions, thus greatly increasing the probability of finding a global optimum.

References

Chen Fangze and Chen Bingzhen. 1996. Training artificial neural network with extended genetic algorithms [J]. Journal of Chemical Industry and Engineering, **47**(3): 280-286.

Fang Yudong, Hao Jianzhong and Yu yinglin. 1994. Genetic algorithms and its application to TSP [J]. Journal of South China University of Technology, **22** (3): 124-127.

Goldberg, D.E. 1989. GAs in Search. Addison Wesley ISDNO-201-15767-5.

Luo Siwei. 1995. A method on genetic algorithm for artificial neural Networks [J]. Journal of Northern Jiaotong University, **19** (4): 541-543.

Zhou Chunguang, Zhang Bing and Cheng Yanfeng. 1996. Genetic algorithm and its application in training feed forward neural Network [J]. MINI—MICRO SYSTEMS, **17**(6):54-58.